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Design Directions for Support of Submarine CO Decision Making

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Two Project Goals

1. **Understand the decision requirements of skilled COs**

   Uncovering the cognitive challenges that systems need to support

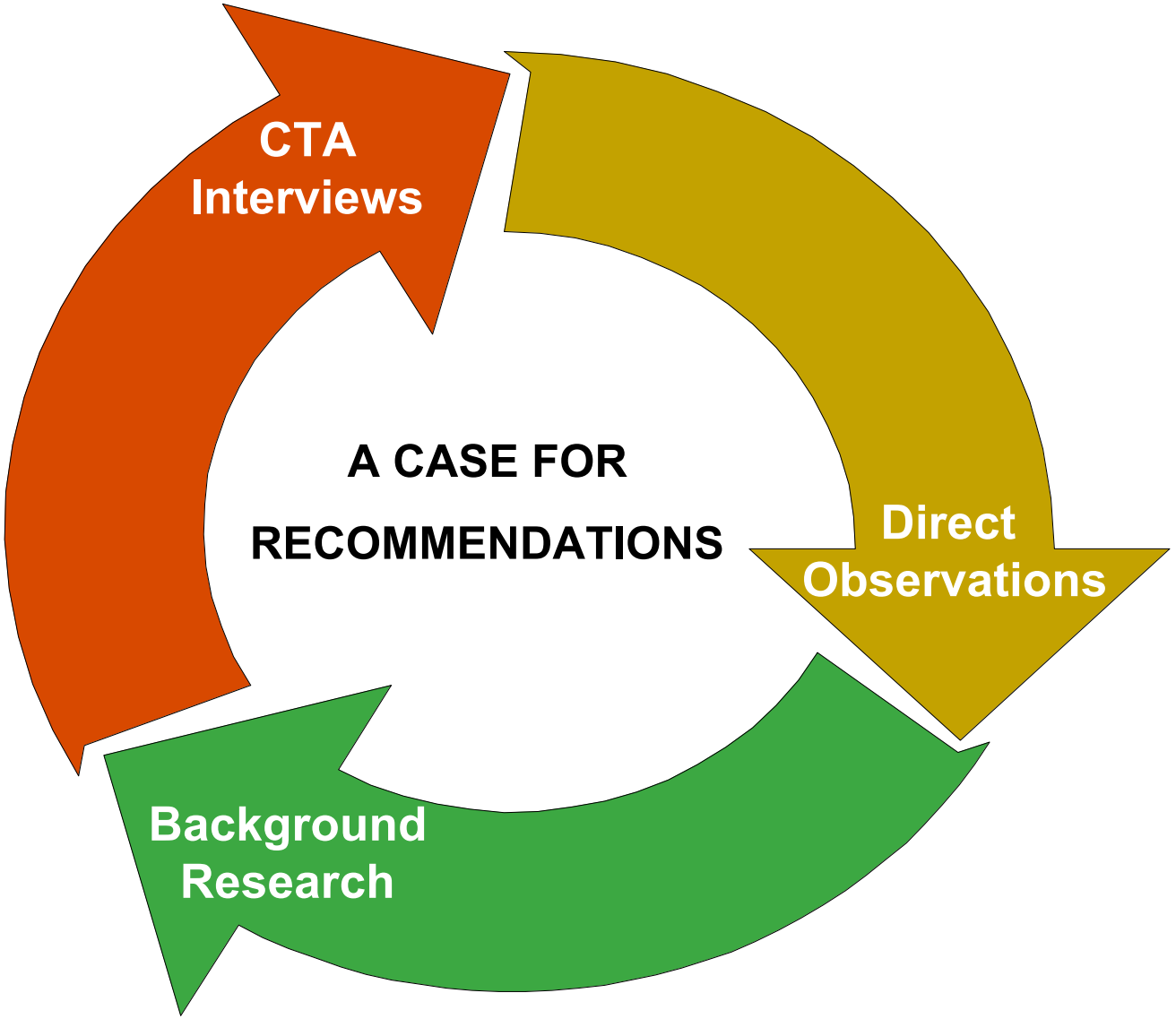
2. **Develop recommendations for the design of technologies to support CO decision making**

   Developing a cognitive case for technology recommendations

Research Process: Data Collection

- **Literature Review**
  - SA displays/Large screen displays
  - Previous Submariner Cognitive Task Analysis
- **19 CTA Interviews with COs**
  - At Norfolk, Groton, & Pearl Harbor
- **Direct Observations:**
  - NSS Attack Center
  - USS Newport News (SCC)
  - USS Albuquerque (surface)
  - USS Virginia (tour)

Multiple Converging Sources



Design Directions Overview

Current Picture

- Vital Signs Display
- Integrated Vertical Slice
- Simplified Contact Management

Future Picture

- Active, Future-Oriented Support
- Spotting Leverage Points
- “What-If” Planning Support

Current Picture Design Directions

1. Integrated Vital Signs Display

- Vital cues for understanding & monitoring are dispersed across displays and locations
  - Lack of interoperability forces CO to manually integrate the collective picture in his head
  - Need for redundancy and constant verbal/written information exchange is a byproduct
- Displays are designed for sitting watchstanders
  - COs have to look/move around the Control Room to get critical information

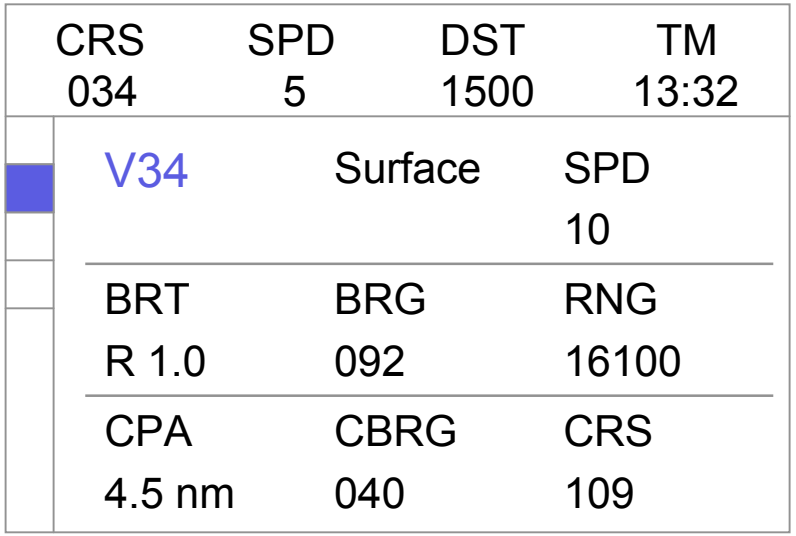
Design Direction #1

Vital Signs Display

A display that allows a CO to stand in Control and constantly get vital ownship information as well as vital information for contacts.

Ownship
course, speed, distance to next point, time constraint

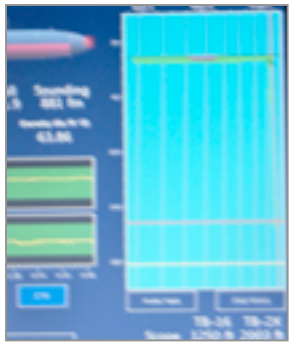
Contact
CPA, estimated range, classification, contact ID, bearing rate, bearing, speed, course



Motivation for Design Direction #2

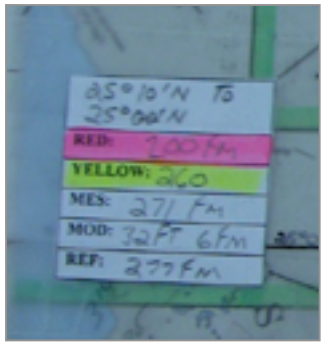
Integrated Vertical Slice

The manual gathering and integration of the vertical slice picture currently



depth history

+



sounding & charted depth

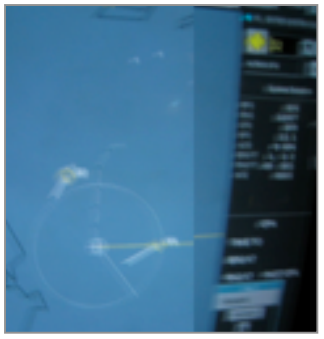
+

ownship depth

+

fathometer & reading histories

+



contact depth

+

depth envelope crew related cues

CO's head

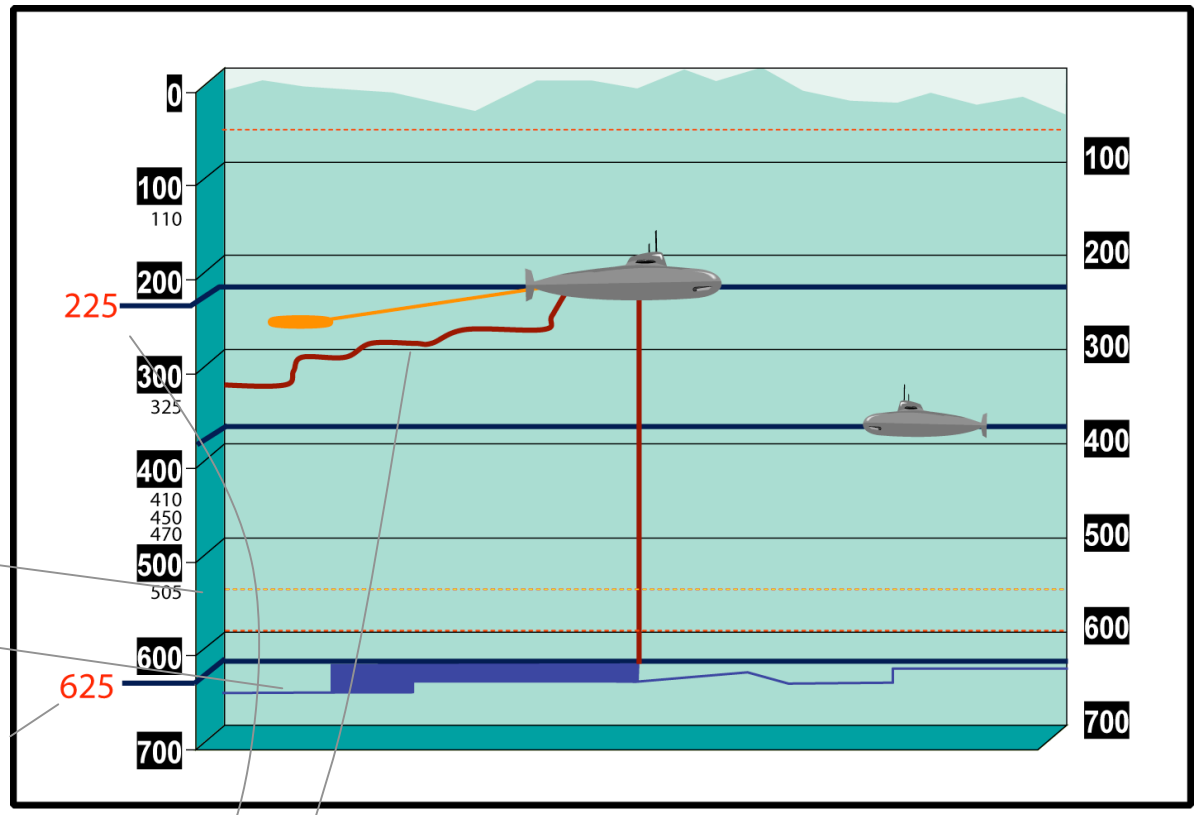
=

Unnecessarily difficult burden to form, maintain, and monitor the vertical picture in an already challenging littoral environment and/or mission

Design Direction #2

Integrated Vertical Slice

Leverages the interoperability of electronic data to maintain a vertical picture that presents vital signs and monitors tripwires.



3. Navigation and Contact Management

- Periods of high risk for Navigation/Contact Management:
  - Littoral operations
  - Getting underway
  - Preparing to surface or come to PD (temporarily blind)
    - Especially tough in arctic conditions and in high-traffic areas
  - Coming into port, especially if unfamiliar
  - Surface transit, especially at night
  - Transiting highly constrained waterways
    - Shallow, lots of traffic, i.e., Straits of Hormuz
- Strategies COs use to deal with high risk:
  - Repeated practice drills
  - Plan extensively for each risky phase
  - Leave flex time
  - Have radar ready to go immediately when surfacing

Design Direction #3

Simplified Contact Management

Display allows operators to triage the contact picture in high density environments by highlighting priority contacts, while monitoring all contacts and tripwires.

- Easily ungroup contacts into individual contacts and regroup them
- The operator will be able to:
  - Group contacts and label boundary cases:
  - Left most, right most, closest
  - Label primary and secondary contacts
- Drill down on single contact to get additional information
  - Classification, course, speed, range, range rate, bearing rate

Future-Oriented Design Directions

4. Active, Future-Oriented Support

CO Characteristics

- COs are different than watchstanders
  - CO lives in the future, sets tripwires, determines track intent, sits "above the fray"

Technology Challenges

- CO can only access passive, repeater displays
  - Displays are designed for area specialists
    - Present and immediate past
    - Not well suited for big picture integration
- Displays cannot be actively engaged for big picture development
- Little support for viewing, monitoring, and sharing the big picture
  - Much must be maintained in his head

Design Direction #4

Active, Future-Oriented Support

Display Features

- Different timescales and scenarios
- Examine different parts of the picture
  - Drill down requirements are different
- Track history
  - How is track history used now?
  - E.g., tracking sporadic contacts over several days or recon
  - E.g., mapping traffic/finding quiet spots
- Different data projection and playback
  - E.g., satellite weather map cycle

5. Uncertainty

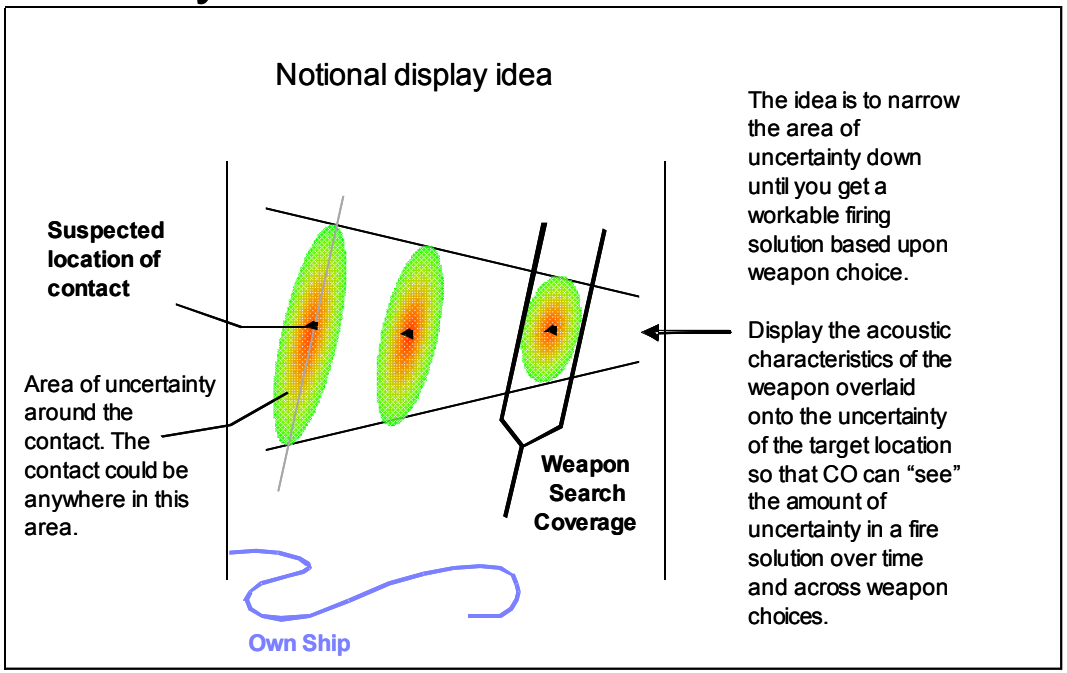
Many CO's cognitive challenges reflect uncertainty

- Submarine systems and missions present uncertainty, but don't help the CO to manage it
  - To shoot or not to shoot? (Is it a biologic?)
  - Have you been detected?
  - Is the enemy within range?
  - Is the FCS telling the truth?
- Need confidence that raw and processed (derived) data are well correlated
- The Goal Pyramid (Safety, Stealth, Mission) is fraught with gray areas and tradeoffs: are we safe and stealthy enough to proceed with the mission?
  - "Every day the CO struggled with meeting the conditions he received from his boss to go in closer. A Sub Commander has discretion on this, can decide how much risk they are willing to take based on comfort level."

Design Direction #5: Managing Uncertainty

Spotting Leverage Points

- "How does making a maneuver affect the target solution—does maneuver X increase or decrease the blob of uncertainty around the contact?"
- Display shows how uncertainty is increased or decreased with each maneuver
- "Cloud of Uncertainty" useful for non-target contact management as well
- Overlay actual data with derived



6. Planning for Options

Planning for Options

- "Want to give yourself as many options as possible when you surface so that you can flex if surface situation isn't what you thought it was"

- "[I'm] thinking about options all along"
  - talking about surfacing in polar ice that was too thin to walk on and too thick to break through safely

- "I assembled a war council of department heads so I could hear what the impact of various options would be from their perspectives"
  - deciding how to get to intercept point for contact of interest in high-traffic area

Design Direction #6

"What-If" Planning Support

Objective: Support COs as they huddle with department heads to "What-If" the situation and during pre-mission planning

- Develop planning display that supports option development
- Permits drawing, projection into future, visualizing how situation could develop based on department heads' input
- Include timeline development tool to help COs build "flex time" into a plan
  - Explicitly show Moving Haven constraints
- Supports building of common ground, sharing of expertise, departure from routine process execution

Summary

- Reported on development of six preliminary design directions based on:
  - Literature Review
  - CTA Interviews
  - At-Sea Observations

Current Picture
- Vital Signs Display
- Integrated Vertical Slice
- Simplified Contact Management

Future Picture
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- Spotting Leverage Points
- "What-If" Planning Support

Next Steps

- Beginning follow-on work to:
  - Identify process threads for priority study
    - Navigation and Contact Avoidance
    - Mission Planning
    - Mission risk assessment and execution
  - Establish cognitive metrics
  - Review existing and developmental technologies

Questions?

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Research Process: Decision-Centered Design

Background research

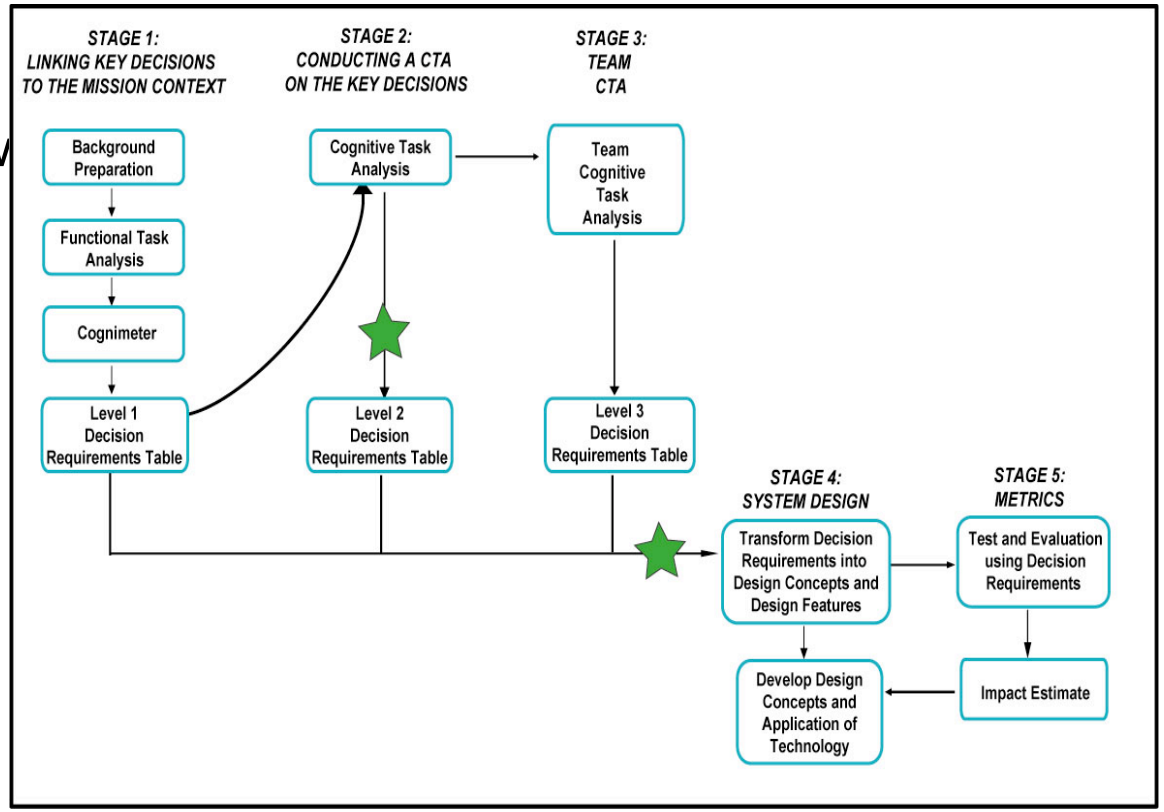
literature review, background reading, review of previous NDM datasets

NDM methods

cognitive task analysis, knowledge audit, direct observation, cognitive assessment

Consolidation

Decision Requirements Table, thematic analysis



Summary: CO Cognitive Challenges

- CO's view is forward looking, predictive
  - COs are trained to operate at the strategic control level: global context, wide event horizon, looking toward the future
  - But the available information pulls a CO down "into the weeds"
- Deployed operations
  - Constant trade-offs among safety, stealth, and mission
- Uncertainty and technology
  - Understanding own location and contact location/intent
- Keeping people proficient, motivated, and performing well
  - In the short term and the long term